

## II.9-FFG FLASH FLOOD AND WATER SUPPLY GUIDANCE

This chapter describes hydrologic guidance and the methodology used by the River Forecast Centers to derive hydrologic guidance values.

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## Flash Flood Guidance

The NWS River Forecast Centers (RFC) prepare and distribute flash flood guidance products which contain rainfall amounts required to initiate flooding. The NWS Flash Flood Guidance System (FFGS) includes techniques and programs for computing flash flood guidance. The method used to compute flash flood guidance is the reverse of the normal use of a rainfall runoff model in which runoff is desired. For flash flood guidance purposes, a specific amount of rain is needed to produce a given amount of runoff based on estimates of current soil moisture conditions as maintained by soil moisture accounting models in the NWS River Forecast System (NWSRFS).

## Types of Flash Flood Guidance

Flash flood guidance values are computed for small streams in an area, e.g., a grid, zone, county or urban area, and for headwaters and additional points downstream where flooding is a problem. Guidance values for small streams in an area are referred to as gridded, zone, county, or urban area guidance depending on the actual area of interest. Guidance values for headwaters and additional locations downstream are referred to as headwater guidance or site-specific guidance.

### Threshold Runoff

Threshold runoff values represent the amount of runoff needed to fill a river or stream channel to slightly over bankfull. For modernization, more accurate threshold runoff values are required and these values are needed on a grid to match the gridded precipitation derived from the WSR-88D radars. The radar precipitation grid is the Hydrologic Precipitation Analysis Project (HRAP) grid which is nominally four km on a side. An objective method of computing threshold runoff has been developed that combines digital elevation, land use and land cover, and river reach data using a geographical information system (GIS) to delineate drainage basins much smaller than the RFCs' forecast basins.

### Current Soil Moisture Conditions

Most RFCs use the National Weather Service River Forecast System (NWSRFS) to simulate soil moisture conditions. This Operational Forecast System (OFS) uses observed precipitation and temperature to determine the mean areal precipitation and snowmelt over the forecast basins. Soil moisture parameters in the model convert the precipitation and snowmelt to runoff which is verified by observed stream stages. The current soil moisture parameters are desired for flash flood guidance computations.

The snow and soil moisture conditions representing the area for which flash flood guidance is to be computed are obtained from previous operations in the segment. The area represented by the flash flood guidance calculations does not have to be the same as that represented by the snow and rainfall-runoff models. The snow and rainfall-runoff operations are used to update the initial conditions from the carryover date to the current time. The current time conditions are those used by the flash flood guidance operation. Within the flash flood guidance operation, the snow model (if selected) and the appropriate rainfall-runoff model are run to generate rainfall-runoff curves for each river forecast basin where areal FFG is desired. Using model representations of the current soil moisture and snow conditions from the database and forecast temperatures (if snow is included), several rainfall values are selected and corresponding runoff values computed to define a rainfall-runoff curve for each river forecast basin. A typical rainfall-runoff curve for a single duration is shown in Figure 1. Curves for 1-, 3-, and 6-hour duration (12 and 24 hour optional) are computed and written to the database. The FFG operation only executes when FFG output is specified in NWSRFS.

### Rainfall Intensity

Under certain conditions, rainfall intensity dominates the computation of areal FFG. The procedure for computing areal FFG involves a combination of FFG based on snow and rainfall-runoff models and FFG based on rainfall intensity. In certain parts of the country, FFG values are based totally on intensity. In other parts, the values computed by the rainfall-runoff model are always used. In some areas, a combination of the two methods provides the best results. In many places where the rainfall-runoff model normally gives the best areal FFG value, intensity is used to control the upper limit that areal FFG can attain (the value under dry conditions). In other areas, where intensity dominates, the intensity-based FFG value varies slightly as a function of the rainfall-runoff FFG value (soil moisture conditions). In addition, intensity-generated FFG values tend to dominate the 1-hour time interval, and rainfall-runoff model produced values become more important as the time interval increases.

There are three general conditions when intensity is dominant. These are:

first, in arid areas or under drought conditions; second, in areas with relatively high soil permeabilities where interflow and baseflow are the only modes of runoff generation when examining an RFC-sized runoff zone; and third, in highly impervious areas. Under all of these conditions, flash floods generally occur from relatively small, highly convective, intense storms. Because existing NWS rainfall-runoff models do not model surface infiltration, runoff for such storms is significantly undercomputed in the first two cases. Special procedures are needed to compute areal FFG in these situations. These procedures are initially rule-of-thumb approaches and may later evolve to more technically based algorithms. In the first and third conditions, the intensity value is initially approximated as an arbitrary but significant portion of the threshold runoff value. Intensity is a dominant factor in flash floods in the Great Plains, Rocky Mountains, portions of the upper Midwest, Florida, coastal areas of the Southeast and Gulf of Mexico, and in highly impervious portions of urban areas.

#### Use of Flash Flood Guidance in the NWS

At the NWS Weather Forecast Offices (WFOs), flash flood guidance is used as the criteria for issuing flash flood watches and warnings and is an indicator of current soil moisture conditions to support hydrologic forecast models available in the WFOs. Flash flood guidance, observed precipitation, forecast precipitation, and radar estimated rainfall are key components in the decision process at the WFOs for the issuance of Flood/Flash Flood Watches/Warnings. Two hydrologic application programs, planned to reside on AWIPS, are being developed specifically for WFOs: the Area-Wide Hydrologic Predictor System (AWHPS) and the Site-Specific Hydrologic Predictor System (SSHPS).

Firstly, the AWHPS is designed to assist the WFO forecasters in assessing flood threat from small streams in the WFO's area of responsibility. The AWHPS consists of a flash flood potential and monitoring components. In the flash flood potential component, observed gridded precipitation from the WSR-88D radar is used to compute projected, gridded precipitation for up to one hour into the future. By applying a statistical algorithm to these observed and projected gridded precipitation accumulation amounts, critical rain probability (CRP) values are computed by comparing the grid accumulation amounts to gridded flash flood guidance provided by the RFCs. Because the CRP values represent accumulation of precipitation over time, the values are most useful during periods of multiple precipitation events.

In the monitoring component, summed amounts of observed and forecast precipitation are compared (monitored) with gridded flash flood guidance. Based on the comparison, the monitor program initiates an audible alarm with a computer-generated message to alert WFO forecasters of a potential flash flood producing rain event. A difference grid, representing the difference between gridded flash flood guidance and observed gridded precipitation, provides an instantaneous "snapshot" of flash flood potential from individual precipitation events. CRP values and difference grids will be displayed in color on background maps of streams, roads, and political boundaries.

Secondly, the SSHPS is designed to assist the WFO forecaster in assessing the flood threat from headwaters or specific stream gaged locations in the WFO's area of responsibility. The SSHPS monitors observed stream gage levels, executes a forecast model using RFC provided soil moisture conditions, generates a stream forecast, and alerts the forecaster when the stream gage level rises to predefined critical levels.

The use of Flash Flood Guidance has increased since first implemented by the National Weather Service in the mid 1970's. Its use will continue to increase to take advantage of the availability of gridded information from both the Advanced Weather Interactive Processing System (AWIPS) and much finer

resolution precipitation estimates from the WSR-88D radars.

Figure 1. Typical Rainfall-Runoff Curve for a Specified Duration

